GeoLab

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What is GeoLab?

GeoLab is a prototype geological laboratory designed for deployment and testing during NASA's analog missions. Johnson Space Center (JSC) scientists built GeoLab as part of a technology project to support the development of science operational concepts on future planetary missions. GeoLab was integrated it into NASA's Habitat Demonstration Unit-1/Pressurized Excursion Module (HDU1-PEM)—a first generation exploration habitat testbed (figure 1).

As a testbed, GeoLab (figure 2) provides a safe, contained working space for crew members to perform preliminary examination and characterization of geologic samples. The GeoLab concept builds from the hardware and protocols used in JSC's Astromaterials Sample Curation laboratories. The centerpiece of the GeoLab is a custom-built glovebox, constructed from stainless steel and polycarbonate, and built to support a positive-pressure nitrogen environment. The glovebox is mounted onto the habitat's structural ribs; the unique shape (trapezoidal prism) fits within a pie-shaped section of the cylindrical habitat. A key innovation of GeoLab is the mechanism for transferring samples into the glovebox—a mechanism composed of three antechambers (airlocks) that pass through the shell of the habitat. These antechambers allow geologic samples to enter and exit the main glovebox chamber directly from (and to) the outside, thereby minimizing potential contamination from inside the habitat. The glovebox also incorporates a state-of-the-art environmental monitoring system. The main chamber of the glovebox is equipped with sensors that monitor oxygen parts per million, pressure millibar, humidity, and temperature, and each antechamber contains pressure sensors. Four video surveillance cameras provide real-time displays of operations inside the GeoLab workstation and the area around the antechamber doors on the outside the habitat.

Fig. 1. *The Habitat Demonstration Unit-1/Pressurized Excursion Module (center) with two docked space exploration rovers. The main module volume includes several workstations. Three circular ports below "Habitat Demonstration Unit" are the antechamber doors that provide access directly into the GeoLab glovebox.*

Fig. 2*. GeoLab integrated into the Habitat Demonstration Unit-1/Pressurized Excursion Module. The suite of instruments included a handheld x-ray fluorescence analyzer (far left), stereomicroscope (center, above glovebox), network cameras, and touch screen computers.*

Configurability

The GeoLab design includes a large set of ports for rapid reconfiguration with new instruments for sample characterization. The initial setup included a stereomicroscope (Leica M80) for microscopic examination and image capture of samples, and an Innov-X handheld Delta DP6000 x-ray fluorescence (XRF) spectrometer for whole rock geochemical fingerprinting. Images and data from the instruments can be saved and "downlinked" to a remote science team. The glovebox also contains a mass balance and scale for collecting sample mass and size. All instrumentation and cameras are controlled at the workstation with two touch-screen computers (HP Touchsmart 600xt) mounted over the workstation and integrated into the HDU1-PEM avionics system. The cameras and sensor displays can be viewed and controlled in real time on the remote network, and data from the microscope and XRF can be quickly moved

Fig. 3. Crew member collecting a geological sample during a Desert Research and Technology Studies traverse.

across the network, thus enabling collaboration between the astronaut crew and a supporting science backroom.

Field Trials

The GeoLab and HDU1-PEM were tested for the first time as part of the 2010 Desert Research and Technology Studies (Desert RATS)—NASA's analog field exercise in Northern Arizona. The demonstration was initially conceived to guide the development of requirements for the Lunar Surface Systems Program and test initial operational concepts for an early lunar excursion habitat that would follow rovers performing geological traverses (figures 1 and 3). GeoLab objectives targeted general support of future planetary surface geoscience activities by providing an infrastructure for preliminary examination of samples, early analytical characterization of key samples, and insight into special considerations for curation, and by using data for prioritization of samples for return to Earth.

GeoLab Operations in the Field

The specific 2010 GeoLab operations included testing basic functions of the glovebox and associated instruments with a variety of operators (figure 4), and supporting the Desert RATS science team with additional data on samples that were collected during the rover traverses. When the crews examined samples in the GeoLab, they were testing these four major objectives at a high level:

1. How does the GeoLab function as a workspace, including glovebox and instrument operations?
2. How well do the crew and science team work together; what benefits are achieved by crew-scientist interactions during the integrated GeoLab tests?
3. Can the data collected in the GeoLab inform the science team about the geologic units and the geologic history of the traverse area?
4. Can the data collected in the GeoLab help the science team prioritize samples for decisions regarding future return to Earth?

Fig. 4. During GeoLab operations, all data could be viewed in near-real time by a remote science team.

Initial GeoLab Results

Results from the GeoLab 2010 operations provide a first look at both the value and the operational constraints associated with human-tended geological operations in a laboratory setting on a planetary surface. Initial assessments suggest that:

1. The GeoLab glovebox provided a high-fidelity field laboratory, and it performed well. With a trained crew, samples could be examined relatively quickly, and provide additional detailed data for further consideration by the science team.
2. GeoLab operations benefited from science team participation. The science team saved valuable crew time by performing certain tasks (e.g., camera control), and guided the crew for decisions regarding data collection.

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3. The detailed data collected in the GeoLab added to the body of evidence applied to understanding the regional geology. Even though initial assessments of the geochemical data include many uncertainties, the full body of data collected on each sample suggests that similar-looking rock units could be distinguished, providing data useful for geologic interpretation of the area (figure 5). Of note, data collected on alteration surfaces of samples provided additional detail and information that was difficult to obtain in the field. The team assumes these data would also be useful to the science team for decisions regarding sample handling and prioritization.

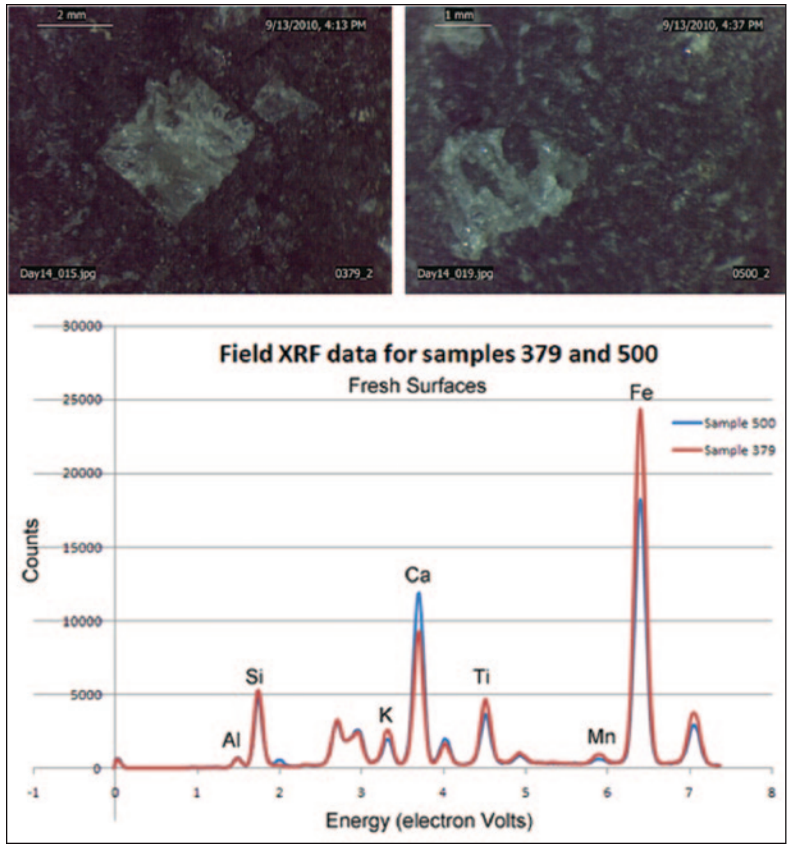

Fig. 5. Microscopic images (texture and phenocryst assemblage) and x-ray fluorescence spectra for rapid geochemical fingerprinting of two samples from similar-looking units [Sample 379, left; Sample 500, right] suggest compositional differences between the older flow unit (500) and an older cinder cone (379).

Future Plans for GeoLab

There are several areas of continued development for future GeoLab operations. The team is testing best operating practices for the XRF as a field/lab instrument, and assessing how to interpret XRF data for whole rock geochemical fingerprinting. Not surprisingly, the GeoLab XRF data must be interpreted within the context of the field occurrence and detailed visual descriptions (especially texture, homogeneity, surface roughness and alteration, and more), and microscopic imagery. The team is characterizing the performance of the XRF spectrometer, in parallel to analysis of Desert RATS data, by conducting tests with rocks of known composition and a variety of surfaces, and by building working calibration curves for the major rock-forming elements. The data will be used for analyzing the results of Desert RATS samples. There is also the plan to test the configurability of GeoLab in the 2011 Desert RATS field tests by integrating additional analytical instruments, and by upgrading and simplifying the instrument interfaces for remote operations. Collaboration will continue with both the science and the operations teams for integrated tests, to take full advantage of the operational environment provided by the field deployment.

Continued testing of GeoLab operations in a field environment will contribute to the development of habitat-based laboratory concepts. The scientific and operational value of additional analytical capabilities will be tested in GeoLab, and, in the future, the results will be compared to similar analyses using field instruments that are operated by crew or instruments mounted on robots. The team aims to apply its work toward defining preliminary examination and sample handling protocols required for efficient field campaigns and initial curation efforts that control contamination and preserve pristine samples collected during exploration missions. Assessment of the laboratory operations will drive the definition of requirements and support the advancement of new technologies for handling and examining extraterrestrial samples, and transporting them back to Earth.